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EXAMINER

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10

Please find below and/or attached an Office communication concerning this application or proceeding.



**DETAILED ACTION**

***Claim Rejections - 35 USC § 103***

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1-7 and 10-13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. (U.S. Pat. No. 5,571,749) in view of Yamazaki (U.S. Pat. No. 6,028,264) and in view of Yamazaki (U.S. Pat. No. 5,556,794), herein referred to as US '749, US '264 and US '794, respectively.

US '749 discloses a method for producing silicon thin films, particularly for use in solar cells, using high-frequency plasma CVD (col. 15, line 9). US '749 discloses forming i-type silicon thin films using a material gas comprising silicon fluoride, hydrogen and oxygen (col. 15, lines 36-53; col. 33, line 60; col. 34, line 12). The flow rate of the hydrogen is usually much higher than the flow rate of the silicon containing gas (see Tables 1-5). The examples shown in US '749 are formed at pressures higher than 50 mTorr (Tables 1-5). US '749 further discloses the use of oxygen-containing gases in the material gas mixture (col. 15, line 34).

The method and thin film of US '749 differs from the instant invention because US '749 does not disclose following:

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- a. The concentration of oxygen contained in the material gas is 0.1 to 0.5 ppm based on a concentration of silicon atoms, as recited in claims 1, 4 and 10; and
- b. The silicon thin film contains oxygen atoms at a concentration of from  $1.5 \times 10^{18}$  atoms/cm<sup>3</sup> to  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup>, as recited in claims 5 and 11.

US '794 and US '264 teach methods for reducing the oxygen concentration in the layers of silicon thin films using molecular sieves or zeolites to adsorb oxygen when forming i-type layers solar cells having pin junctions (US '264 col. 6, line 20). US '264 teaches the formation of an i-type silicon thin film layer having an oxygen concentration less than  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup> and as low as  $5.0 \times 10^{18}$  atoms/cm<sup>3</sup> (col. 6, line 26). US '794 teaches the formation of an i-type silicon thin film less than  $5.0 \times 10^{18}$  atoms/cm<sup>3</sup> or as low as  $5.0 \times 10^{15}$  atoms/cm<sup>3</sup> (col. 8, line 62; col. 9, line 44).

Regarding claims 5 and 11, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the silicon thin film of US '749 to use a thin film having an oxygen concentration of  $1.5 \times 10^{18}$  atoms/cm<sup>3</sup> to  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup> as taught by US '264 and US '794 because oxygen in the intrinsic layer of solar cells act as donor centers and decreases the photo-sensitivity of solar cells (US '794 col. 3, lines 19-42).

Claims 5 and 11 are product-by-process claims, and as such, if the product is the same as or obvious from a product of the prior art, the claim is unpatentable (see MPEP § 2113). Since all of the references teach the use of a CVD method and US '794 and

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US '264 disclose the oxygen concentration in the final product, the instant claims would have been obvious over the prior art.

Furthermore, in light of the fact that US '794 and US '264 teach the formation of silicon layers having the specified oxygen concentration, and because the oxygen concentration that is deposited is dependent on the concentration contained within the material gas, it would have been inherent in the fabrication process of US '794 and US '264 to have used a material gas with an oxygen concentration of 0.1 to 0.5 ppm based on the concentration of silicon atoms. Using the specified process, a different oxygen concentration would have yielded a different concentration of oxygen in the deposited layer.

3. Claims 8 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. (U.S. Pat. No. 5,571,749) in view of Yamazaki (U.S. Pat. No. 6,028,264) and in view of Yamazaki (U.S. Pat. No. 5,556,794), as applied to claims 1-7 and 10-13, and further in view of JP 2000-77694. References to JP 2000-77694 are made using the column and line number references of Higashikawa (U.S. Pat. No. 6,252,158), herein referred to as US '158, which is the U.S. patent in the JP 2000-77694 patent family.

US '749, US '264 and US '794 disclose a method and silicon thin film having the limitations recited in claims 1-7 and 10-13 of the instant invention, as explained above in section 2. The method and device described by US '749, US '264 and US '794 further differs from the instant invention because they do not disclose having a crystalline

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Raman scattering at least three times greater than the Raman scattering due to amorphous components.

Raman scattering shows the level of crystallization within silicon layers. The ratio of crystalline component to amorphous component gives a measurement for the crystal volume within the layer, i.e., a film having a crystalline component with a Raman scattering three times greater than the Raman scattering of the amorphous component has a crystal volume of 75%.

US '158 teaches a solar cell structure having several microcrystalline intrinsic layers with crystal volumes ranging from 30% to 99% (col. 11, line 66 to col. 12, line 3). Microcrystalline silicon solar cells avoid "the optical degradation phenomenon (Staebler-Wronski effect) specific to the amorphous semiconductors" (col. 2, lines 47-52).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the silicon thin film described by US '749, US '264 and US '794 to use a thin film having a crystalline Raman scattering three times greater than the amorphous Raman scattering, as taught by US '158, because a higher crystalline Raman scattering helps avoid the deleterious effects of optical degradation associated with amorphous semiconductors (US '158 col. 2, lines 47-52).

4. Claims 9 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. (U.S. Pat. No. 5,571,749) in view of Yamazaki (U.S. Pat. No. 6,028,264) and in view of Yamazaki (U.S. Pat. No. 5,556,794), as applied to claims 1-7 and 10-13, and further in view of JP 11-310495. References to JP 11-310495 are made using the

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column and line number references of Kondo (U.S. Pat. No. 6,103,138), herein referred to as US '138, which is the U.S. patent in the JP 11-310495 patent family.

US '749, US '264 and US '794 describe a method and silicon thin film having the limitations recited in claims 1-7 and 10-13 of the instant invention, as explained above in section 2. The silicon film described by US '749, US '264 and US '794 further differs from the instant invention because they do not disclose having a diffraction intensity of the (220)-plane comprising at least 50% of the total diffraction intensity.

US '138 teaches the use of thin films having diffraction intensities in the (220)-plane at least 30% of the total diffraction intensity because "the thin film will have notably improved carrier mobility" (col. 3, lines 37-40). US '138 further discloses specific examples of thin films having diffraction intensities in the (220)-plane from 50% to 60% relative to the total diffraction intensity (table 2).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the thin film of US '749, US '264 and US '794 to use a thin film having a diffraction intensity in the (220)-plane at least 50% of the total diffraction intensity, as taught by US '138, because using such a thin film will have a "notably improved carrier mobility" (US '138 col. 3, lines 37-40).

### ***Double Patenting***

5. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA

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1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and, *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

6. Claims 1-15 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-16 of copending Application No. 09/865,549 in view of Yamazaki (U.S. Pat. No. 6,028,264) and in view of Yamazaki (U.S. Pat. No. 5,556,794), herein referred to as App. '549, US '264 and US '794, respectively.

Claims 1, 2, 5, 6, 11 and 12 of App. '549 claim a method and silicon thin film formed using a silicon halide and hydrogen, wherein the silicon halide is a silicon fluoride. Claims 3, 7 and 13 recite the limitation that the flow rate of hydrogen is not less than the flow rate of the silicon halide. Claims 4, 8 and 14 recite the limitation that the pressure is 50 mTorr or more. Claims 9 and 15 recite the limitation that the Raman scattering from a crystalline component is at least three times greater than the Raman scattering from an amorphous component. Claims 10 and 16 recite the limitation that the percentage of diffraction intensity for the (220)-plane is at least 50% of the total diffraction intensity.

App. '549 differs from the instant invention because App. '549 does not disclose having oxygen present in the material gas at a concentration or from 0.1 ppm to 0.5 ppm, as recited in claims 1, 4 and 10, and a oxygen concentration in the formed silicon



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film having a concentration of  $1.5 \times 10^{18}$  atoms/cm<sup>3</sup> to  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup>, as recited in claims 5 and 11.

US '794 and US '264 teach methods for reducing the oxygen concentration in the layers of silicon thin films using molecular sieves or zeolites to adsorb oxygen when forming i-type layers solar cells having pin junctions (US '264 col. 6, line 20). US '264 teaches the formation of an i-type silicon thin film layer having an oxygen concentration less than  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup> and as low as  $5.0 \times 10^{18}$  atoms/cm<sup>3</sup> (col. 6, line 26). US '794 teaches the formation of an i-type silicon thin film less than  $5.0 \times 10^{18}$  atoms/cm<sup>3</sup> or as low as  $5.0 \times 10^{15}$  atoms/cm<sup>3</sup> (col. 8, line 62; col. 9, line 44).

Regarding claims 5 and 11, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the silicon thin film of App. '549 to use a thin film having an oxygen concentration of  $1.5 \times 10^{18}$  atoms/cm<sup>3</sup> to  $5.0 \times 10^{19}$  atoms/cm<sup>3</sup> as taught by US '264 and US '794 because oxygen in the intrinsic layer of solar cells act as donor centers and decreases the photo-sensitivity of solar cells (US '794 col. 3, lines 19-42).

Claims 5 and 11 are product-by-process claims, and as such, if the product is the same as or obvious from a product of the prior art, the claim is unpatentable (see MPEP § 2113). Since all of the references teach the use of a CVD method and US '794 and US '264 disclose the oxygen concentration in the final product, the instant claims would have been obvious over the prior art.

Furthermore, in light of the fact that US '794 and US '264 teach the formation of silicon layers having the specified oxygen concentration, and because the oxygen

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concentration that is deposited is dependent on the concentration contained within the material gas, it would have been inherent in the fabrication process of US '794 and US '264 to have used a material gas with an oxygen concentration of 0.1 to 0.5 ppm based on the concentration of silicon atoms. Using the specified process, a different oxygen concentration would have yielded a different concentration of oxygen in the deposited layer.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

### ***Response to Arguments***

7. Applicant's arguments filed on February 26, 2003, have been carefully considered, but are not persuasive.

8. As explained in the rejections set forth above, the formation of silicon films using silicon fluoride and hydrogen as a material gas in a high-frequency plasma enhanced CVD process is known. Furthermore, US '794 and US '264 disclose the oxygen concentration of the final silicon film product within the claimed range. Both US '794 and US '264 disclose the formation of silicon layers using plasma CVD process (see col. 6, lines 16-20 and col. 6, lines 34-44, respectively). US '264 specifically discloses the use of silicon fluoride. US '794 discloses an example of forming a silicon film using silane and identifies the problem of high oxygen concentrations in silane material gases (col. 8, lines 23-36). Both US '794 and US '264 seek to reduce the amount of oxygen in the final silicon film using zeolites. This reduction results in a concentration of oxygen

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within the range recited in the instant claims. Since the final silicon film product has the same concentration as the silicon film in the instant claims, it is expected that the material gas would also have an oxygen concentration within the claimed range. This expectation is justified because the concentration of components in the material gas directly affects the concentration of components in the final film. In other words, in a plasma CVD process, the concentration of components in a film is directly dependent on the concentration of the material gas. A different oxygen concentration would have yielded a different concentration of oxygen in the deposited layer.

9. Applicant has argued, "both Yamakazi '264 and Yamakazi '794 may actually *teach away* from Claim 1, because those references are understood to teach *removing* as much oxygen as possible from the material gas used to form 'a non-single-crystal semiconductor layer'" (see page 8 of Applicant's response). Applicant further states, "one of ordinary skill would understand that the Yamakazi references are directed to forming amorphous semiconductor layers (see column 5, lines 36-39, of Yamakazi '264)" (see pages 8-9 of Applicant's response).

10. Regarding Applicant's argument, Yamakazi does teach the reduction of oxygen from the material gas. Yamakazi has identified that high oxygen concentrations are detrimental to the performance of solar cells, and that silane gases contain more oxygen than is desirable. To solve this problem, Yamakazi has disclosed a method for reducing the concentration of oxygen in the material gas. The reduction of oxygen in the material gas produces silicon films having an oxygen concentration within the range recited in the instant claims. Therefore, it would be expected that the material gas also

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has an oxygen concentration within the recited range because the concentration of components in the product film is dependent on the concentration of components in the material gas.

11. Regarding Applicant's statement regarding the crystallinity of the silicon film produced, it is noted that the crystallinity of the silicon-based thin film is not claimed in claims 1, 4 and 10 of the instant invention. Furthermore, in column 5 at lines 36-39 of Yamakazi '264, an example is provided wherein the non-single crystal film comprise "amorphous, semi-amorphous, or microcrystalline form" materials. The phrase "non-single crystal" is used by those in the art to refer to any material that is simply not made of a single crystal, i.e., not monocrystalline. Non-single crystals comprise amorphous, microcrystalline and polycrystalline morphologies. Semi-amorphous compounds are comprised of amorphous and crystalline structures.

### ***Conclusion***

12. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of


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the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Brian L. Mutschler whose telephone number is (703) 305-0180. The examiner can normally be reached on Monday-Friday from 8:00am to 4:30pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (703) 308-3322. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9310 for regular communications and (703) 872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

  
NAM NGUYEN  
SUPERVISORY PATENT EXAMINER  
TECHNOLOGY CENTER 1700

blm  
March 19, 2003